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SCIENCE

FRIDAY, DECEMBER 10, 1909

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THE FOOD SUPPLY OF THE FUTURE¹

FROM various sources we have heard of late warnings of a deficiency in the food supply of the future population of the United States.

Thus President James J. Hill in his address before the Bankers' Association, and more elaborately in his recent article in *The World's Work*, sets forth in striking terms the growth of our population and the present limits of wheat production and predicts a shortage of not less than 400,000,000 bushels by the middle of the present century unless radical improvements in the prevailing methods of farming are speedily inaugurated.

Davenport, in his address at the dedication of Agricultural Hall at the University of Maine, calculates that if the rate of increase of population in the past one hundred years be maintained, the end of the twentieth century will see us with a population of twelve hundred millions, and emphasizes the fact that the agriculture of the future must be enormously productive in order to feed these teeming millions. He says:

The conditions that have just been discussed will not be temporary and transient; they will be enduring, yes, permanent, and they must be met by a permanent agriculture—a thing the world has never yet succeeded in establishing. No race has ever yet learned to feed itself except at the expense of the fertility of its own or some other country. Other races have come up against this problem and have gone down under it. . . .

There is to be, in the very near future, a struggle for land and the food it will produce

¹ Presidential address delivered before the American Society of Animal Nutrition at Chicago, Ills., November 27, 1909.

such as the world has never yet beheld. He who knows where and how to look can see it coming. The African activity among western European nations is a part of it. It is always cheaper to move when over-population and failing fertility threaten a shortage of food—providing there is any place to move into; that is, providing we can dispossess the other party and his land is worth the contest.

However that may be as an abstract proposition, for us there is no moving. For us there are no more "new worlds." For us there is little more "out west." Our fortune and our future, whatever they may be, are staked down on the American continent. Literally, "here we rest," and whether we like it or not, we must devise and establish a permanent agriculture or go down in the attempt.

Much the same general line of thought was followed by President J. L. Snyder in his annual address before the Association of American Agricultural Colleges and Experiment Stations, but with special emphasis on the social significance of a straitened food supply. He said:

... agriculture has contributed to democracy more than we can estimate by furnishing our people with an abundant food supply. So fertile has been our land, so extensive our fields, so abundant our harvests of grain and fruit, that the best and highest grades of food have been within the reach of every citizen who has been willing to do an honest day's work. It matters not what his occupation and social position, be they ever so humble. He and his family enjoy practically the same kinds of food as that enjoyed by families of wealth and prominence. In the dinner pail of the man who works in the mill, in the mine, or digs the ditches in our city streets, can usually be found wheat bread, meat, butter, fruit and coffee. What more does any one have? ...

Caste and class distinction can make little headway among a people who all live on the same kind of food. As long as the working man has in his tin pail as good a dinner as his superintendent or as the mayor of his city, his prejudices will be moderate. He will maintain his self-respect and feel and act the man. It is when the pangs of hunger begin to pinch that men give way to prejudice and passion.

After pointing out that unless the food supply keeps pace with the increase of population, there will not be enough of the better foods to go around, he says:

The history of other countries tells us what would soon follow. Two families could not or would not occupy the same pew in church while one lived on white bread and meat and the other on black bread and potatoes. There is a social distinction there that can not be bridged. They would not even attend the same church or belong to the same social organizations. Our people would separate into classes and become estranged from each other. The power usually goes with wealth, but the men compelled to live on cheap food would soon get into the same political party and perhaps gain control of the national government.

and quotes from a letter of Lord Macaulay to an American friend as follows:

... The day will come when the multitudes of people, none of whom has had more than half a breakfast or expects to have more than half a dinner, will choose a legislature. Is it possible to doubt what sort of a legislature will be chosen? ... There will be, I fear, spoliation. The spoliation will increase the distress; the distress will produce fresh spoliation. ... Either civilization or liberty will perish.

Even if we question the estimates of rate of increase in population on which these warnings are based, and however much weight we may attach on the other hand to estimates of increasing agricultural production per acre, it would be foolish in the extreme to close our eyes to the fact that the intensity of the demand for food by our future population will exceed anything we have yet known. Whether this state of affairs is to come about more or less rapidly is important chiefly as it gives us more or less time to prepare for it.

This is not the occasion to discuss problems of crop production nor of the conservation of soil fertility, but there are other aspects of the question which intimately concern us as stock feeders.

The problem of food supply is essentially

a problem of energy supply. While a small proportion of our food during the earlier years of life serves to build up the bodily machinery, by far the larger part of it is simply the vehicle by means of which chemical energy is introduced into organism, to be liberated again as work or heat in the performance of the vital functions. Briefly and crudely stated, food is the fuel of the body. The ultimate source of this energy, so far as we are concerned, is the sun. Crops are produced by means of solar radiation and food represents the stored-up energy of the sun's rays. The continuance of life upon the earth is conditioned upon the ability of the plant to effect this storage of energy and the density of population which a country can support from its own resources is limited absolutely by the amount of solar energy which can be recovered in the form of food products.

In view of this absolute dependence on solar radiation, it is a rather startling fact that the larger part of the energy stored in an acre of crop is contained in inedible products. From one half to two thirds of the organic matter of the corn crop, for example, is contained in the stover and cobs and about sixty per cent. of that of the average wheat crop in the straw. Furthermore, grain itself is not adapted for direct consumption by man, but undergoes various processes of preparation, giving rise to numerous unavailable by-products. For example, in the milling of wheat, about 25 per cent. of the grain passes into the offals and only 75 per cent. serves for purposes of human nutrition. In other words, out of the total energy stored up by the growth of an acre of wheat only about 30 per cent. serves directly for the nutrition of man. Substantially the same thing is true in greater or less degree of other food crops, while the

grasses and leguminous forage crops which play so important a rôle in modern agriculture are, of course, entirely useless as human food.

It is clear that as population becomes denser and agriculture more intensive, it will become essential to utilize the energy of these by-products as completely as possible. When we number 500,000,000 we can not afford to throw 60 per cent. of the energy of the wheat crop into the manure heap if it is possible to save any of it. The agency for effecting this saving is our domestic animals. They are able to consume these by-product materials which man can not use and to render available a portion of their energy, using it in the first instance to support their own lives, but also storing up for man's use a certain part of what would otherwise be a total waste. As the demand for food grows more intense, it will become increasingly important to so husband these by-products and combine them into efficient rations, and to feed these rations under such conditions and to such types of animals, as to save the largest possible percentage of the energy which they contain.

It scarcely need be said that we are still far from doing this. Our rations are too often faulty and fed to inferior animals under unfavorable conditions, and only a short railway journey is necessary to convince one of the enormous waste of forage taking place every year, while our by-product feeding stuffs compete with native products in the markets of the old world.

With our relatively sparse population, this has hitherto been a country not only of cheap food, but especially of cheap meat, and we have been fond of drawing the contrast between the diet of our laborers, with its abundance of animal food, and that of the European laborer, and whether rightly or wrongly, have attributed much of the

greater efficiency of our workmen to this difference in diet. This abundant meat supply has been drawn especially from the vast corn fields of the Mississippi valley. Not only have our by-products gone to waste, but material available as human food has been converted into meat and milk. While this concentration of grain into higher priced and more marketable products has been in the past and to a degree still is entirely justified economically, nevertheless, the conversion of corn, or of any food grain, into meat is an exceedingly wasteful process. Jordan² computes that in the production of beef or mutton only about 2½ per cent. of the digestible organic matter consumed by the animal is recovered as human food in the edible portion of the carcass, while even in pork production this percentage rises to only about 15½ per cent. Facts like these make it evident that we can not continue indefinitely to use edible grains as stock food—to take the children's bread and cast it to the beasts. The waste of energy in the transformation is too great. Nor is it any answer to say that wheat and not corn is the bread grain of the western world. The irresistible economic pressure of population will sooner or later compel us either to use corn as human food or to utilize the land now devoted to corn culture for other crops which shall yield more available nutriment, while the stockman will be forced to utilize by-product feeds to the utmost, not simply as a means of continuing meat as a prominent ingredient of our diet nor of providing animal foods as luxuries for the tables of the wealthy, but primarily as a means of conserving energy for human use. The feeder of the future will utilize by-product feeds to an extent as yet unrealized. He will pass in review the crude products of

the farm, and all the hundred and one wastes of manufacturing operations, to see if perchance they still contain energy which he can extract. Like the miner, he will be ready to work low-grade ore, provided there is a sufficient margin of profit. Even the small amounts of available energy contained in such feeds as oat hulls, corn cobs and the like will be utilized and their waste energy saved as rapidly and as far as economic conditions render profitable, and to aid in rendering this possible is to render service to mankind.

It must be clearly understood, however, that this desirable end is not to be attained by any species of pious fraud. The manufacturers of mixed feeds are of late making much of the importance of by-product materials, a most sound proposition in itself, but one which hardly justifies all the corollaries which some of them appear to draw from it. That corn cobs, for example, contain a certain small amount of available energy does not render it an act of benevolence to induce the farmer to feed them, as Mike wanted his whiskey supplied, "unknownst," in some mixed feed with a high-sounding name or as an inconspicuous admixture to some well-known material. Such surreptitious kindness is in danger, in the long run, of recoiling upon its author. We shall not effect the needed economies of the future by coaxing or beguiling the feeder into utilizing these low-grade materials as ingredients of patent feeds or pre-digested mixtures or ready-balanced rations, but by teaching him their true value and educating him to make his own mixtures and balance his own rations. Personally, I am opposed on principle to mixed feeds, as I am to mixed fertilizers, not because many of them are not good of their kind, but for the reason that they minimize the intelligence of the farmer while they open a wide door for fraud on

² "The Feeding of Animals," 5th edition, p. 405.

the part of unscrupulous manufacturers and dealers.

The questions which we have been considering are very broad ones. They signify nothing less than a revolution, no less real because gradual, in the methods of agriculture as a whole and of the production of animal foods in particular, and the conditions which we must expect in the future will call for a much higher degree of skill in adapting means to ends than has been necessary in the past. What, then, should be the attitude of the institutions for agricultural teaching and research toward the problem of the future food supply?

Hitherto a large share of our experiments in feeding have had for their chief aim the improvement of present practises. They have sought to demonstrate how we may most efficiently convert grain into meat rather than how much of it can be saved for man's direct use. While such experiments have been of undoubted immediate utility, yet we shall soon have to reverse the point of view. Our experiment stations must take up in earnest the conservation rather than the exploitation of food resources, and our agricultural colleges, while still teaching the approved practises of the present, must as their chief aim seek to equip their students with a sound knowledge of underlying facts and laws and thus prepare them to meet the changing conditions of the future. In passing, too, I can not forbear calling attention to the fact that such an attitude toward the subject of animal husbandry and such methods of teaching it will serve to impart to it a higher pedagogic value than it generally has at present and will tend to make it a disciplinary as well as an informational subject.

Investigation of the questions here outlined must be of as broad and comprehen-

sive a character as the problems to be solved. It should proceed, as I view it, along two main lines.

The first of these is a far more extensive and profound study of the scientific principles of animal nutrition than has yet been made.

That he may utilize the materials of which I have been speaking as completely as possible, the stockman needs to know in the first place what proportion of the energy which these various materials contain it is possible or practicable to recover. This knowledge will enable him to effect a wise selection in the compounding of rations, as well as have an influence upon the whole system of farming. In the second place, he needs to know the relative efficiency of different species, breeds and types of animals as converters of energy and how their efficiency is influenced by their natural or artificial environment.

These, however, are questions of animal physiology. In effect they ask how does the animal mechanism operate when supplied with different raw materials or placed under varying conditions. They are problems for rigorous scientific research and too much stress can not be laid upon the importance of such research. A well-known investigator, in a private communication from which I am permitted to quote, says:

If we are to find new things, to get new ideas and to establish new lines of practical experimentation, we must first increase our field of opportunity by discovering new facts of general application. The progress of every branch of applied science has been made in this way and agriculture as well as the mechanic arts has shared in the benefits. The immense improvements of recent years in agricultural practise are largely founded on the purely scientific investigation of the preceding generation. The progress of the future must be founded on the scientific research of the present. That researches directed to immediate practical results frequently fail to yield all

that may be expected of them is largely due to the imperfections of the scientific work of the past and so makes evident the importance of undertaking in the present purely scientific studies which will lead to more definite and valuable results when future experiments are directed to the solution of practical problems.

No field of study opens so widely or presents so many opportunities for gaining knowledge of untold practical importance as that of animal nutrition.

As an illustration of the importance of gaining information respecting the fundamental problems of nutrition, the knowledge gained during the last few years respecting the constitution of the proteins may be mentioned.

As a result of these recent discoveries the whole question of protein assimilation is put in an entirely new light, multitudes of new questions are raised which must be answered before the feeding of these substances can be carried out on a scientific and intelligent basis. Heretofore in conducting feeding experiments proteins have been assumed to be of equal nutritive value and no definite evidence has been obtained which shows whether or not this is so. The wide differences in the constitution of the proteins of different animal and vegetable tissues at once raises the question of their relative nutritive value and the best methods of feeding them. Definite information respecting the nutritive value of each of the proteins commonly employed for food can not fail to show the way to new experiments with the use of commercial feeding stuffs and ought sooner or later to show the way to more productive and economical uses of these foodstuffs. A similar knowledge of the actual nutritive relations of phosphorus-containing substances³ would likewise doubtless lead to similarly important results and deserves far more attention from a purely scientific standpoint than it has yet received.

Concerning all these questions we know something, but how little this is in comparison with what remains to be discovered. These are hard problems but they must be solved, before agricultural practise can have the benefit of what science can do for it.

Such work is intensely individual in character. The prime factor is the man. The principal service, and a highly impor-

³The experiments of McCollum, at the Wisconsin station, published since this was written, are most important on this point.

tant one, which an organization can render is to aid in providing the opportunity. Such service I earnestly hope our society may be able to perform, especially in the direction of impressing upon public sentiment as represented in legislative bodies, on the one hand, and upon the minds of benevolent men of wealth, on the other, hand, the fundamental importance of scientific research for the successful solution of the problem of the future food supply.

The other main line of experimental effort relates to the economic application in practise of the principles discovered by scientific investigation. Along this line, as I see it, there is a wide field open for fruitful experimental work, but this aspect of the subject was so fully dealt with last year in the report of the committee on organization that it seems superfluous to enter into it anew at this time.

Finally, along both lines of effort, but especially the second, there should be a coordination of effort and of spirit combined with the largest possible scope for individual initiative. This society owes its origin largely to a feeling of dissatisfaction over the more or less fragmentary and elementary nature of our past work. The discussions of the Cornell conference and of the last annual meeting of the society, as well as the incorporation into its constitution of the provision for a committee on experiments, clearly shows a desire on the part of investigators for closer relations with each other and a more broadly conceived program of investigation. It is hoped that the meetings of this society and the work of its committee may at least be serviceable in defining problems and improving methods.

But no program of agricultural investigation can be truly national in its scope which does not include the greatest agricultural agency perhaps in the world—

certainly the predominant one in this country—the United States Department of Agriculture. No one would think of intimating that this great department has neglected the interests of the stockmen of the United States, but nevertheless, it is true that until very recently its work for them has been chiefly of the nature of veterinary and inspection work, as indeed it still is to a relatively large extent. The Bureau of Animal Industry has, it is true, established a dairy division and has begun to take up problems of feeding and especially of breeding with the modest appropriation for this purpose which congress has put at its disposal. The department should be put in position to do much more than it is doing, however. Its work in this field should be productive as well as protective. If the development of our waterways and the conservation of our forests, mines and water powers are subjects of national concern, surely the conservation of the food supply is worthy of attention. The magnitude of the live stock industry in itself, and especially its important relations to the future food supply of the nation which I have been endeavoring to point out, are such as to amply warrant the department in entering upon comprehensive investigations, both scientific and practical, into this subject and to fully justify congress in making all necessary appropriations. It is not alone our food supply, but our democracy, which is at stake.

It goes without saying that such an effort on the part of the national government should be made in harmony with the investigations which may be undertaken by other agencies. All the available forces should unite in the study of these important questions and no local jealousies should be allowed to stand in the way. While there may be problems of coordina-

tion and correlation still to be solved, I am confident that they are readily solvable, while it seems not impossible that in some respects this society might advantageously serve as an unofficial intermediary between state and national authorities.

I congratulate the society upon the notable increase in its membership during the past year and upon the very encouraging attendance upon its first annual meeting. If I understand the spirit and temper of its members, they desire to make the society something more than a pleasant club or a gathering for the reading of papers. It is my hope, which I believe I share with every member, that it may become an active agency in forwarding the solution of some of the problems which I have attempted to indicate in this address.

H. P. ARMSBY

A DEFENCE OF SANITY¹

EVER since the reign of the illustrious Emperor Augustus, when Horace taught that all men are mad, there has been a wide-spread belief in the truth of the Roman poet's assertion. Yet few of us are wholly mad, and we shall not go far astray if we agree with a modern essayist that "every man has a sane spot somewhere." The actual degree of insanity from which any one of us suffers is a matter difficult of determination, since it can be made known only through the verdict of one's peers, who themselves in turn are demented. One can arrive at a correct judgment in an individual case only by comparing it with that which the most intelligent of the multitude, after long study and deep knowledge, have established as the norm. Any pronounced diversion from

¹An address delivered at the opening of the fifty-seventh year of the College of Medicine of the University of Vermont, Burlington, November 3, 1909.